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Charles Darwin: Shaping our Science, Society and Future

ABSTRACTS OF PRESENTATIONS

Since 2009 marks the 200th anniversary of the birth of Charles Darwin and the 150th anniversary of his most seminal work on evolutionary biology *On the Origin of Species ...* , the Northern Territory Government and Charles Darwin University sponsored a free public symposium held in the city of Darwin between 22 and 24 September to honour the life and achievements of this extraordinary man. His legacy has extended beyond biology and into the humanities and social sciences. This symposium presented opportunities to appreciate and debate Darwin's findings and his legacy. The symposium was organised under the Northern Territory Government and Charles Darwin University Partnership Agreement and arranged by a Steering Committee headed by Dr Richard Willan and Professor Robert Wasson representing the Government and the University, respectively.

Following a Welcome Reception at Parliament House hosted by the Chief Minister, The Honourable Paul Henderson MLA, delegates moved to the Darwin Convention Centre to hear a presentation on the life of Charles Darwin. The Symposium itself was divided into three themes across the next two days. National and international speakers reflected on the impact of Charles Darwin on their research in biology, medicine and history. The first theme was entitled 'Brave new world: what is Darwin's legacy in the era of modern medicine, biotechnology and technology-based societies?' The second theme was entitled 'Understanding the controversy between Darwinian science and religion'. The third theme was entitled 'Social Darwinism and indigenous nations: the origin of socio-political policy'. The titles of the presentations by the keynote speakers and their abstracts are as follows.

Charles Darwin: the concise history of an extraordinary man

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Charles Darwin is often considered the most influential scientist who ever lived because the theory of evolution is one of the most powerful ideas in science and may well be the greatest idea ever had by the human mind. 2009 is the 200th anniversary of Darwin's birth and the 150th anniversary of the publication of *On the Origin of Species ...* . His message of descent with modification through natural selection presented in 1859 in *The Origin* precipitated a paradigm shift – the replacement of one world view by another. Darwin changed the way humans view their place in nature. He showed that humans were not above nature, but part of it. He supplied an explanation for the great diversity of life and showed that all life, including human, is related by descent from a common ancestor. No other biologist has had an impact of this magnitude. In the words of the eminent geneticist Theodosius Dobzhansky: "Nothing in biology makes sense except in the light of evolution". The paradigm shift from creation to evolution has allowed a staggering array of advances in knowledge.

Darwin was born into a wealthy English family on 12 February 1809. He was educated at Edinburgh and Cambridge Universities and graduated 10th in his class of 178 at Cambridge in 1831. He was offered the unpaid position as naturalist-companion to Captain FitzRoy on the second voyage of H.M.S. *Beagle* from 1831-1836 on a surveying mission around South America. He considered this experience the first real education of his mind. The geology and biodiversity he experienced in rainforests, the pampas, the Andes, the Galapagos Islands, and on coral reefs influenced his thinking and the history of science. Darwin sent back 1529 species bottled in alcohol and 3907 dried specimens.

Darwin (1837) drew the first evolutionary tree to show the relatedness of all animal life. He explained how coral reefs form (1842) and contributed to geological observations on earth movements (1844) and the deformation theory of metamorphic rock (1846). He described all known barnacle species, fossil and living (1851–1854). Darwin explained how orchids are fertilised by insects (1862) and how plants climb (1865). He introduced the "control" in "controlled experiment" and he catalogued the bewildering variation in domestic plants and animals (1868). He explained human origins and sexual selection in ways never before articulated (1870–1871), and discussed human and animal emotions in similar terms (1872). The latter work was one of the first books to use photographs to illustrate a point. Darwin showed how insectivorous plants growing on impoverished soils utilise nitrogen-rich insects (1875), and he demonstrated that the offspring of cross-fertilised plants were more numerous and vigorous than self-fertilised ones (1876, 1877). His observations of climbing plants laid the foundation for the field of plant growth hormones (1880), and his work on earthworms (1881) is a classic study in ecology. Any one of these achievements could constitute a life's work for most scientists.

Evolutionary biology – the tree of life as a framework for comparative biology

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Evolutionary biology has undergone a renaissance of phylogenetic thinking and associated methods. While the phylogenetic concept has been around since Charles Darwin, only recently has the field of phylogenetics developed into a rigorous research endeavour. In this talk, I develop the idea of articulating evolutionary histories through the estimation of phylogeny, motivate the study of the Tree of Life, and provide examples of how this knowledge of evolutionary relationships provides a powerful tool to study a wide variety of questions in biology. I provide examples of the application of phylogenetic questions to organismal biology (Crustacea), medicine (infectious diseases including HIV) and conservation biology.

Co-evolution of infection and immunity

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Infection shows us evolution at work in our day-to-day world. The overall pace of genetic adaption for slowly-reproducing, multi-cellular, multi-organ systems like us is glacial when compared with the rate of change possible for the plethora of unicellular (bacteria, protozoa) or sub-cellular (viruses) organisms that seek to survive and multiply on our body surfaces (skin, mucosa) or within our tissues. As a consequence, vertebrates have evolved a very complex, broad-spectrum immune defence system to combat this process of parasitism. Conceptually, immunity is comprised of two distinct, but interactive components. Innate immunity provides a set of 'first response' mechanisms, some of which (like phagocytosis) go back to the very beginnings of biology. Elements of the slower-developing, but more targeted adaptive immune response are first seen in the lampreys and the jawed fish from 350–450 million years ago. Though birds and mammals share the basic characteristics of adaptive immunity, like specific 'killer' T cell and antibody-mediated effector function and memory, there has been considerable divergence through phylogenetic time in the way that the various elements are organized. When it comes to RNA viruses, we can see the interface between the selective pressures imposed by immunity and rapid molecular evolution operating at first hand, either on a population basis (influenza) or within the infected individual (HIV). Other one-host DNA viruses like the Herpesviruses and Poxviruses provide us with examples of long-term convergence as individual members of these virus groups have evolved much the same mechanisms to temper the consequences of immune control in the various species that they infect. In general, the fact that we can suffer autoimmune diseases makes it clear that immunity is an evolved rather than a designed system, with all the inherent compromises that are inevitable as species build on pre-existing mechanisms to adapt through time.

Drilling for Darwin: Rescuing the science of evolution from beneath layers of controversy

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"My Dear Darwin … I finished your book yesterday." With these words Thomas Huxley began his November 1859 letter to Charles Darwin that would presage a series of reactions to *On the Origin of Species* … . Darwin's bold model for the diversity of life that we see on Earth was indeed groundbreaking science. However, reactions to this new view were immediate and varied. Huxley ultimately saw this as an argument against the Church of England and the entrenched position of the clerics. Herbert Spencer, who coined the phrase "survival of the fittest", applied the evolutionary model to social, political, and economic systems. Darwin's cousin, Francis Galton, argued for steps to control the breeding of the human population in order to force the selection of certain traits, establishing the field of eugenics.

On the other side of the discussion, religious commentators were also reacting. Those who held to a literalist interpretation of Genesis were quick to argue against the implications of Darwin's proposal. Others, who were more in the mould of St. Augustine in their approach to scripture, could accept the scientific implications but were less convinced of the social and theological interpretations. In any case, it was clear that the science of biological evolution was quickly being buried beneath strata of controversial and decidedly non-scientific interpretative schemes.

This situation has continued until the present. We witness what the press calls the "evolution wars" being waged between the new militant atheists and the creationists and intelligent design advocates, each flying banners emblazoned with Darwinian, or anti-Darwinian slogans. And yet the science of evolution, especially when coupled with Mendel's understanding of inheritance, has become the central paradigm of biology, leading us to an expanded understanding of how the living world functions.

All of these positions are scientifically and philosophically flawed. Creationism and intelligent design are not scientific and also not theologically sound. The neo-atheist position may have philosophical positions, but these conclusions are not directly related to or provable by the science of evolution.

I propose a different approach. Theistic evolution is the broad and peaceful middle ground between these factions. In this view, the science of evolution is championed as the most reasonable explanation for the observed data, and the model that has been most fruitful in opening new avenues of investigation. However, the theological, philosophical, and social arguments are pried away from the scientific framework. For a theistic evolutionist, a belief in God is not in opposition to the science of evolution. While an atheist may disagree with this, the science of evolution does not justify that disagreement.

Darwin and the ascent of emotionally modern man: how humans became such other-regarding apes

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As proposed by Charles Darwin, humans are remarkably similar to other apes. Like their larger brained, bipedal 'cousins', Great Apes also use tools and exhibit a rudimentary understanding of causality and Theory of Mind. However, other apes fall short of humans in intention-reading and co-operation. In this lecture I explain why I am convinced that the psychological and emotional underpinnings for apes to care so much about what others intend and feel emerged as a by product of shared parental and alloparental care and provisioning of young, what sociobiologists refer to as 'co-operative breeding'. According to widely accepted chronology, large-brained, anatomically modern humans evolved around 150 000 years ago, and behaviourally modern humans, capable of symbolic thought and language, more recently still, between 50 000–80 000 years ago. But (I argue) emotionally modern humans, newly interested in the mental and subjective states of others and characterised by prosocial impulses to give and share, emerged far earlier along with what, for an ape, was a peculiar mode of rearing young.

Indigenous epistemologies and social Darwinism

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During Charles Darwin's voyage in the South Pacific in the 1800s, the foundations of modern scientific research and its ontological and epistemological pillars were being set in history. The inclusion of Pacific Indigenous peoples within such history was always as an object of study and never the producer or the consumer of research. Modern science today and its investigative methods are not detached from the social and historical circumstances of its origin. This paper will argue that from across Darwin's 'imagined' South Pacific, Indigenous researchers are forging a new intellectual agenda which I call Contemporary Critical Indigenous Scholarship. This agenda seeks new and robust ways to conduct research while revealing insights on the role the Indigenous intellectual.

Darwinism and the Victorian soul: the reception of Darwin's theory of human evolution in the 19th century and beyond

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In an 1871 cartoon in the British magazine *Punch*, an earnest young husband reads to his wife and infant child from Charles Darwin's just-published book *Descent of Man*. "So you see, Mary, baby is descended from a hairy quadruped, with pointed ears and a tail," he explains. "We all are." His wife counters: "Speak for yourself, Jack. I'm not descended from anything of the kind, I beg to say; and baby takes after me."

This was the general attitude toward the question of human evolution in much of English-speaking world at the time *Descent of Man* arrived, a question cast into the spotlight by British naturalist Charles Darwin. Although the general concept of organic evolution was quickly and widely accepted by British and American scientists and much of the educated public, the specific case of humans – or at least distinctly human characteristics – proved more problematic. From the time his *On the Origin of Species* ... was published in 1859, scientists and others on both sides of the Atlantic had hotly debated the proposition that humans evolved from animals even if they accepted evolutionism generally. Review the editorial cartoons, read the scientific commentary, and the basic sentiment toward the idea is almost always the same: Most people simply refused to believe their highly developed minds, morals or emotions evolved from those of beasts.

In some ways, little has changed in the past century. Many otherwise committed evolutionists draw the line on materialism when it comes to the ascent of man. Oxford ornithologist David Lack, whose 1947 study of Darwin's finches gave wing to the modern neo-Darwinian synthesis, believed: "Science has not accounted for morality, truth, beauty, individual responsibility or self-awareness, and many people hold that, from its nature, it can never do so." The American geneticist Francis Collins, who directed the Human Genome Project and now heads the National Institutes of Health, wrote: "Science will certainly not shed any light on what it means to love someone, what it means to have a spiritual dimension to our existence, nor will it tell us much about the character of God." His words continue a debate that began in the Victorian Era.

RNA as the engine of complexity: a new view of human evolution and genomic planning

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It appears that the genetic programming of humans and other complex organisms may have been misunderstood for the past 50 years, because of the assumption – largely true for prokaryotes, but not for multicellular eukaryotes – that most genetic information is transacted by proteins. The human genome comprises three billion base pairs of DNA sequence information. It programs the development of a precisely sculptured individual of about 100 trillion cells with hundreds of different muscles, bones and organs, as well as the brain. It contains about 20 000 conventional protein-coding genes, surprisingly about the same number and in large part with similar functions as those in tiny worms that have only 1000 cells. On the other hand, the extent of non-protein-coding DNA does increase with increasing complexity, reaching 98.8% in humans, suggesting that much of the information required to program human development may reside in these sequences. This is supported by the observation that regulatory information scales quadratically with function, indicating that as complexity increases a greater proportion of the genome is devoted to regulation and that prokaryotes were limited in their complexity by a protein-based system, a problem the eukaryotes solved as a prerequisite to the appearance of developmentally complex species in the Cambrian.

Consistent with this proposition, recent studies have shown that the majority of the mammalian genome is transcribed, mainly into non-protein-coding RNAs, and that there are tens of thousands of long and short RNAs in mammals that show specific expression patterns and subcellular locations, especially in the brain. There is increasing evidence that these RNAs control gene expression at many levels, and comprise a massive hidden regulatory network that directs the precise patterns of gene expression during growth and development. Indeed, RNA-directed regulatory circuits underpin most, if not all, complex genetic and epigenetic phenomena in eukaryotes. Moreover, the editing of RNA (which has expanded in the vertebrates and especially in the primates) appears to be the means by which environmental signals modify epigenetic

information, especially in the brain, thereby comprising the molecular basis of learning and the evolution of cognition. Thus, rather than simply being a passive intermediate between DNA and protein, RNA may represent the computational engine of the cell, becoming become progressively more sophisticated in more complex organisms. Thus, what was dismissed as junk because it was not understood may hold the key to understanding human evolution, development and intelligence, as well as our physical and psychological idiosyncrasies and susceptibilities to common diseases. Finally, the observation that some RNA-directed epigenetic changes can be inherited raises the intriguing question: has evolution learnt how to learn?

The then and now of Social Darwinism for Indigenous Australia: imagining a different future

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The bi-centenary of Charles Darwin's birth could also mark the end story of Social Darwinism in Australia. But an alternative narrative of country and race requires a paradigm shift in which the evolutionary gaze is swung 180 degrees from the Indigene to the non-Indigene: a re-imagining of non-Indigenous self-concept and belongingness. This paper develops this idea by juxtaposing eras of Darwinian influenced terrain: the 1830s and 1840s and the 1990s and 2000s with a different vision for the era 2010 onwards. In February 1836, when Darwin visited what was known to the Europeans as Van Diemen's Land, he had no or little contact with Aboriginal people. By then the last traditional people were imprisoned and dying at Wybalenna. If we fast forward to 2009 and imagine Darwin revisiting, again his Aboriginal contact would likely be sparse. Except in commodified objects such as dot paintings, or as anthropological curiosity, the Indigenous is absent from the nation's view of itself and Indigenous peoples remain locked in what I refer to as the domain of Aboriginality. Darwin's work rationalised the Tasmanian destruction post event via the concepts of evolutionary inevitabilities and Social Darwinism and Darwin himself contributed by requesting Tasmanian skulls. In contemporary times the iterations and societal adaptations of these concepts still echo into Indigenous lives. The socio-cultural hierarchy replaced the Chain of Being, but the imprint of the latter is embedded in the shape and interpretation of the former. How can the post-2010 era be different? The paradigm shift I propose reverses the discourses of evolutionary inevitabilities with the pivotal re-imagining the narrative of non-Indigenous evolvement of interaction and relating to country, perceptions of Australia's identity and conceptions of fit within the land and its heritage. Indigenous understandings and peoples are inevitably central to these imaginings.